

What is Claimed:

- 1 1. An apparatus for manipulating a load, said apparatus comprising:
2 a first support structure for supporting the load;
3 a second support structure for supporting the load; and
4 a coupling coupled between said first support structure and said second
5 support structure, said coupling including a compliant mechanism for providing a
6 compliant range of motion to the load about a rotative axis where a center of gravity of
7 the load is located away from said rotative axis, said rotative axis being a non-vertical
8 axis.
- 1 2. The apparatus of claim 1 wherein said compliant mechanism is
2 configured to be adjusted manually to account for variations in the load.
- 1 3. The apparatus of claim 1 wherein said compliant mechanism
2 includes at least one pneumatic actuator.
- 1 4. The apparatus of claim 1 wherein said compliant mechanism
2 includes at least one spring.
- 1 5. The apparatus of claim 1 wherein said coupling provides at least
2 one additional range of motion to the load in a direction or about an axis.
- 1 6. The apparatus of claim 1 wherein said apparatus is a manipulator
2 for manipulating a test head for testing integrated circuits.
- 1 7. The apparatus of claim 1 wherein said second support structure
2 supports said load through a second coupling, said second coupling providing the load
3 with a range of motion about a second rotative axis.
- 1 8. The apparatus of claim 1 wherein said first support structure
2 provides the load with a first substantially vertical range of motion, said second support
3 structure provides the load with a second substantially vertical range of motion, said
4 second substantially vertical range of motion being different from said first substantially
5 vertical range of motion.
- 1 9. The apparatus of claim 8 wherein at least one of said first
2 substantially vertical range of motion and said second substantially vertical range of
3 motion is a compliant vertical range of motion.
- 1 10. The apparatus of claim 9 wherein a position of the load within said
2 compliant vertical range of motion is adjusted by adjusting a fluid pressure supplied to
3 said apparatus, the fluid pressure being adjusted via a control unit located away from
4 said apparatus.
- 1 11. A method of manipulating a load, said method comprising the
2 steps of:
3 providing a first support structure for supporting the load;

4 rotatively coupling the first support structure to a second support
5 structure for supporting the load about a rotative axis such that a center of gravity of
6 the load is located away from the rotative axis, the rotative axis being a non-vertical
7 axis;

8 providing a compliant range of motion to the load about the rotative axis;
9 and

10 manipulating the load about the rotative axis using the compliant range
11 of motion.

1 12. The method of claim 11 wherein said manipulating step includes
2 manually adjusting the load about the rotative axis.

1 13. The method of claim 11 wherein said step of providing a
2 compliant range of motion includes operating at least one pneumatic actuator
3 positioned between the first support structure and the second support structure.

1 14. The method of claim 11 wherein said step of providing a
2 compliant range of motion includes providing at least one spring between the first
3 support structure and the second support structure.

1 15. The method of claim 11 further comprising the step of:
2 providing at least one additional range of motion to the load through a
3 coupling between the first support structure and the second support structure.

1 16. The method of claim 11 further comprising the step of:
2 rotatively coupling the second support structure to the load to provide
3 the load with a range of motion about a second rotative axis.

1 17. The method of claim 11 further comprising the steps of:
2 providing the load, through the first support structure, with a first
3 substantially vertical range of motion; and
4 providing the load, through the second support structure, with a second
5 substantially vertical range of motion, the second substantially vertical range of motion
6 being different from the first substantially vertical range of motion.

1 18. The method of claim 17 wherein at least one of the first
2 substantially vertical range of motion and the second substantially vertical range of
3 motion provided is a compliant vertical range of motion.

1 19. The method of claim 18 further comprising the step of:
2 adjusting, via a remote control unit, a position of the load within the
3 compliant vertical range of motion by adjusting a fluid pressure which at least partially
4 provides the compliant vertical range of motion.

1 20. An apparatus for manipulating a load, said apparatus comprising:

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2 a first support structure for supporting the load, said first support
3 structure providing the load with a first substantially vertical range of motion;

4 a second support structure for supporting the load, said second support
5 structure providing the load with a second substantially vertical range of motion
6 relative to said first substantially vertical range of motion; and

7 a coupling between said first support structure and said second support
8 structure, said coupling providing at least one additional range of motion to the load in
9 a direction or about an axis, the additional range of motion not being in a substantially
10 vertical direction.

1 21. The apparatus of claim 20 wherein at least one of said first
2 substantially vertical range of motion and said second substantially range of motion is a
3 compliant vertical range of motion.

1 22. The apparatus of claim 21 wherein a position of the load within
2 the compliant range of motion is adjusted by adjusting a fluid pressure supplied to said
3 apparatus, said fluid pressure being adjusted via a control unit located away from said
4 apparatus.

1 23. The apparatus of claim 20 wherein said apparatus is a
2 manipulator for manipulating a test head for testing integrated circuits.

1 24. The apparatus of claim 20 wherein said coupling is a rotative
2 coupling.

1 25. The apparatus of claim 24 wherein said rotative coupling includes
2 a compliant mechanism for providing the additional range of motion as a rotative
3 compliant range of motion about a rotative axis.

1 26. The apparatus of claim 24 or 25 wherein said second support
2 structure supports said load through a second rotative coupling, said second rotative
3 coupling providing said load with a rotative range of motion about a second rotative
4 axis.

1 27. The apparatus of claim 25 wherein said rotative axis is not
2 rotative about a substantially vertical plane.

1 28. The apparatus of claim 20 wherein said at least one additional
2 range of motion includes a substantially horizontal range of motion.

1 29. A method of manipulating a load, said method comprising the
2 steps of:

3 moving the load to a first position within a first substantially vertical
4 range of motion of the load, the first substantially vertical range of motion being
5 provided by a first support structure;

6 moving the load to a second position within a second substantially
7 vertical range of motion of the load relative to the first substantially vertical range of
8 motion, the second substantially vertical range of motion being provided by a second
9 support structure; and

10 providing a coupling between the first support structure and the second
11 support structure, the coupling providing an additional range of motion to the load in a
12 direction or about an axis, the additional range of motion not being in a substantially
13 vertical direction.

1 30. The method of claim 29 wherein at least one of the first
2 substantially vertical range of motion and the second substantially vertical range of
3 motion is a compliant range of motion.

1 31. The method of claim 30 further comprising the step of:
2 adjusting a position of the load within the compliant range of motion by
3 adjusting a fluid pressure which at least partially provides the compliant range of
4 motion.

1 32. The method of claim 29 wherein said step of providing a coupling
2 includes providing a rotative coupling between the first support structure and the
3 second support structure.

1 33. The method of claim 32 wherein the rotative coupling provides a
2 rotative compliant range of motion to the load about a rotative axis.

1 34. The method of claim 32 or 33 further comprising the step of:
2 providing a second rotative coupling between the second support
3 structure and the load, the second rotative coupling providing the load with a rotative
4 range of motion about a second rotative axis.

1 35. The method of claim 29 wherein said step of providing a coupling
2 includes providing a coupling between the first support structure and the second
3 support structure, the coupling providing the additional range of motion to the load in a
4 substantially horizontal direction.

1 36. An apparatus for remotely changing a position of a regulating
2 control device, the regulating control device regulating a force for at least partially
3 supporting a load, said apparatus comprising:

4 a remote unit for varying a fluid pressure, the variation in fluid pressure
5 corresponding to a change in the position of the regulating control device in at least
6 one direction;

7 a coupling coupled between said remote unit and the regulating control
8 device, said coupling being configured to change the position of the regulating control
9 device based on the variation in fluid pressure; and

10 a fluid carrier for providing the change in fluid pressure from said remote
11 unit to said coupling.

1 37. The apparatus of claim 36 wherein the regulating control device is
2 configured to regulate the force for at least partially supporting the load in a compliant
3 state in a direction or about an axis.

1 38. The apparatus of claim 37 wherein the regulating control device is
2 configured to regulate the force for at least partially supporting the load in a compliant
3 state in a substantially vertical direction.

1 39. The apparatus of claim 36 wherein the change in position of the
2 regulating control device results in a change in a position of the load within a range of
3 motion of the load in a direction or about an axis.

1 40. The apparatus of claim 39 wherein the change in position of the
2 regulating control device results in a change in a position of the load within a range of
3 motion of the load in a substantially vertical direction.

1 41. A method of remotely changing the position of a regulating control
2 device, the regulating control device regulating a force for at least partially supporting a
3 load, said method comprising the steps of:

4 varying a fluid pressure, via a remote unit, where the variation in fluid
5 pressure corresponds to a change in the position of the regulating control device in at
6 least one direction;

7 providing the change in fluid pressure, via a fluid carrier, from the
8 remote unit to a coupling coupled between the remote unit and the regulating control
9 device; and

10 changing the position of the regulating control device through the
11 coupling based on the variation in fluid pressure.

1 42. The method of claim 41 wherein said step of changing the position
2 of the regulating control device results in a corresponding change in the force, the force
3 at least partially supporting the load in a compliant state in a direction or about an axis.

1 43. The method of claim 42 wherein the force at least partially
2 supports the load in a compliant state in a substantially vertical direction.

1 44. The method of claim 41 wherein said step of changing the position
2 of the regulating control device results in a change in a position of the load within a
3 range of motion of the load in a direction or about an axis.

1 45. The method of claim 44 wherein the change in the position of the
2 load within the range of motion is in a substantially vertical direction.

1 46. An apparatus for manipulating a load, said apparatus comprising:

2 a support structure for supporting the load, said support structure
3 providing the load with a *range of motion*, said *range of motion* being a compliant
4 range of motion; and

5 a remote unit for adjusting a fluid pressure of a fluid system through a
6 fluid carrier, the fluid system providing at least a portion of the force for supporting the
7 load within the compliant range of motion,

8 wherein an adjustment of said fluid pressure via said remote unit adjusts
9 the force for supporting the load.

1 47. The apparatus of claim 46 wherein said remote unit is configured
2 to adjust said fluid pressure to balance the load in a substantially weightless condition
3 within the *compliant range of motion*.

1 48. The apparatus of claim 46 wherein said remote unit is configured
2 to adjust said fluid pressure to adjust a position of the load within the compliant range
3 of motion.

1 49. A method of manipulating a load, said method comprising the
2 steps of:

3 providing a support structure for supporting the load, the support
4 structure providing the load with a compliant range of motion; and

5 varying a fluid pressure through a fluid carrier, via a remote unit, where
6 the fluid pressure provides at least a portion of a force for supporting the load within
7 the compliant range of motion.

1 50. The method of claim 49 wherein said varying step includes
2 varying the fluid pressure to balance the load in a substantially weightless condition
3 within the compliant range of motion.

1 51. The method of claim 49 wherein said varying step includes
2 varying the fluid pressure to adjust a position of the load within the compliant range of
3 motion.

1 52. A method of manipulating a load, said method comprising the
2 steps of:

3 at least partially supporting the load in a compliant state in a direction or
4 about an axis by pressurizing a fluid, such that the load may be moved in the direction
5 or about the axis using a first manual amount of force; and

6 remotely adjusting the fluid pressure such that the load may be moved in
7 the direction or about the axis using a second manual amount of force until an operator
8 can manipulate the load in the direction or about the axis, the second manual amount
9 of force being less than the first manual amount of force.